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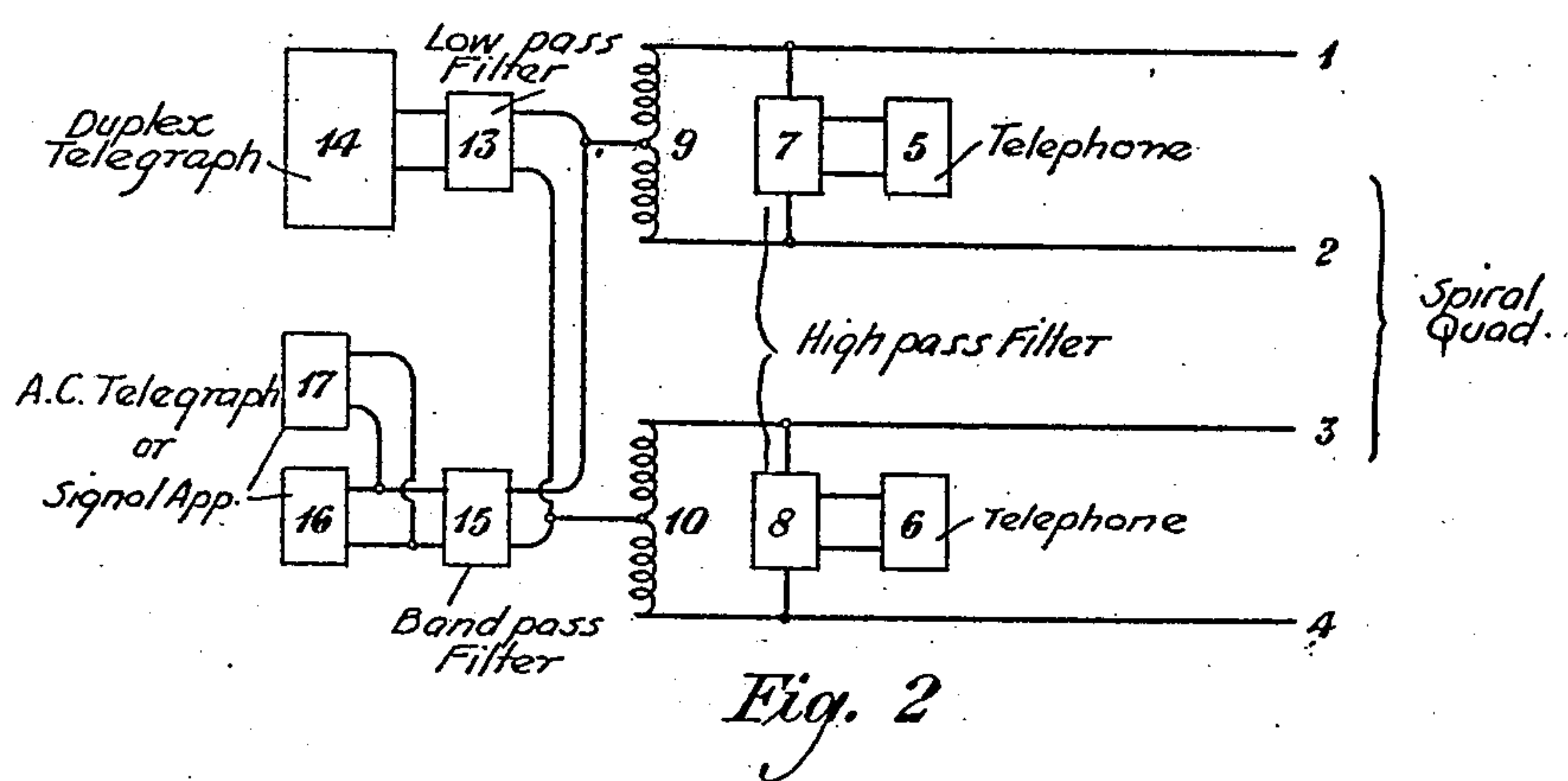
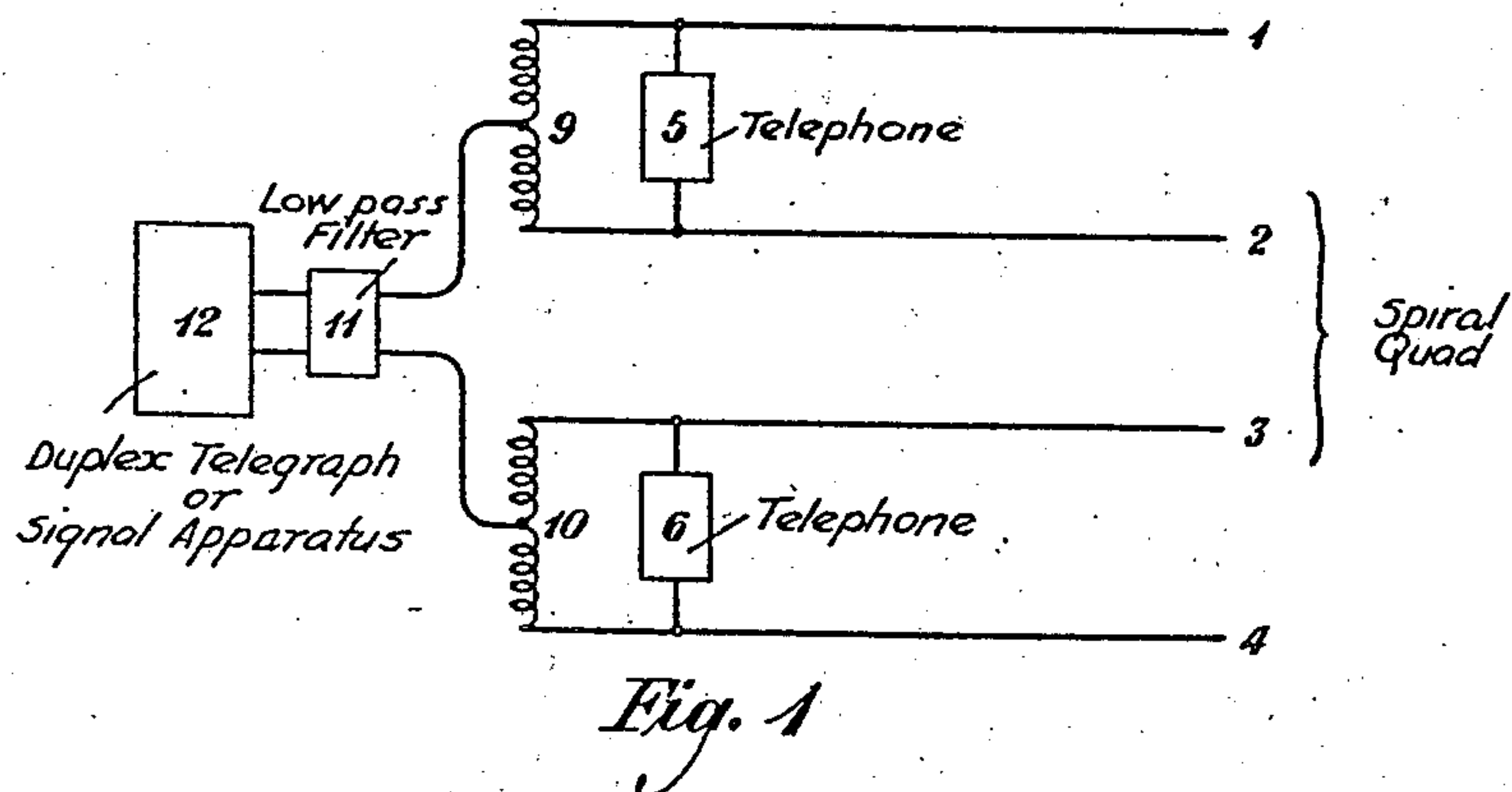
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O. SATTELBERG

LONG DISTANCE CABLE

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## UNITED STATES PATENT OFFICE.

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## LONG-DISTANCE CABLE.

Application filed January 5, 1926, Serial No. 79,458, and in Germany February 29, 1924.

My invention refers to telegraph and telephone cables and more especially to long distance cables. It is an object of my invention to provide a long distance cable which can be used not only for the transmission of telegrams but also for telephonic intercourse. This is the more important in the case of the modern long distance cables.

In the majority of cases the long distance cables hitherto used are formed in multiple-twin formation, i. e., with the two conductors of a circuit twisted together and two pairs of such conductors again twisted together to form a quad each group of four wires giving three speaking connections. The sending of telegraphic messages through these channels can be effected in two ways. In the United States the superposition principle is used as a rule, the messages being sent through speaking wires with direct current voltage. In contradistinction thereto in Germany the tendency prevails to operate these cables for telegraphic purposes with alternating voltages and to use currents the frequency, strength and intensity of which are within the range of the speaking currents and voltages. It is thus possible to employ the channels available in such case for telegraphic and for telephonic purposes, as required in each individual case.

As regards the construction of the long distance cables, it has been proposed to replace the multiple-twin formation by the spiral quad formation i. e., an arrangement in which the four conductors of a quad are all twisted together simultaneously. In the latter case, owing to the comparatively high side-to-side capacity of the spiral quad formation the phantom circuits cannot be utilized for speaking purposes to the same extent as the phantom circuits of multiple-twin cables; (for well-known reasons the quads cannot be used for telephonic purposes). The phantom telephone circuits can, however, readily be dispensed with inasmuch as, in the same cross-sectional area, a spiral quad cable can accommodate approximately 50% more pairs of conductors than a multiple twin cable. There results therefore in both systems practically the

same number of speaking channels. As far as the operation is concerned, the spiral quad formation, in which merely the side circuits are utilized, is superior to the multiple-twin formation in several respects; however, owing to the larger consumption of copper the first costs are about 10% higher.

The present invention is based on the idea that the use of the spiral quad formation, leaving aside the phantom speaking connections, is warranted as soon as it is possible to bring forward some further advantages of an economical and of an operative kind. This can be accomplished according to this invention by utilizing merely the side circuits for telephonic purposes, while reserving the phantom connections for signaling and telegraphy. It is thus possible to accommodate in each phantom circuit a high-grade telegraph duplex connection or several signaling connections, or if desired both telegraph and signaling connections together, without the telephonic intercourse in the speaking connections being unfavorably influenced. The several kinds of connections are held apart in this arrangement by the range of the frequencies used in each case. While direct current high speed telegraphy in the majority of cases only requires frequencies up to 75-100 cycles, the signaling connections operated by alternating current are operated with frequencies up to about 200 cycles. The speaking frequencies proper, which range above 300 cycles, are not used as a rule according to this invention.

It is further important to note that the transmission of the frequencies which are used for telegraphic and signaling purposes is possible over sufficiently long distances in spiral quad circuits without coil-loading or continuous loading. The absence of loading, apart from the saving of costs, entails the further advantage that the telegraphs inserted in the phantom connections may easily be worked duplex.

If a cable in multiple-twin formation with  $n$ -side circuits, and therefore  $n+n/2=3n/2$  channels, is compared with a spirally twisted



cable with  $3n/2$  pairs, the installation of the latter cable will cost 10% more, but if operated in accordance with this invention, it will offer the possibility of obtaining  $3n/4$  high-grade telegraph connections workable in duplex and therefore warrants not only an operative but also a commercial superiority.

According to the idea underlying this invention the telegraph instruments are worked in the metallic circuits, hereinafter styled telegraph loops, both legs of which consist of two equal circuits, each of which is as a rule only used for speaking purposes. In this arrangement it is possible to form each telegraph loop from two physical circuits as well as from two phantom circuits.

All such circuits will never be entirely symmetrical and a balancing of discontinuities requires considerable expenditure. According to this invention the mutual absence of disturbance between the telegraph loop and its two component circuits is obtained without balancing the cable, by depriving the current impulses used for telegraph and signaling purposes of the harmonics falling within the range of the speaking frequencies. This may for instance be effected by inserting in series with the telegraphic equipment a filter having a range of transmission up to about 150-250 cycles. A filter of this kind will further act towards barring the way through the telegraphic equipment to all audio-frequent unbalance currents as may arise from the unavoidable lack of symmetry of the cable, whereby a very material source of disturbances is done away with. By further inserting filters which do not transmit sub-audio frequencies in the telephonic equipments whereby telegraph currents are prevented from entering into the latter, thus insuring a complete mutual absence of disturbance.

It is further important that the mutual protection of the side circuits on the one hand and the phantom circuit on the other hand does not require any balancing of the differences in capacity at the loading points nor any other balancing means to be distributed over the whole cable line. According to this invention mutual absence of disturbance is solely obtained by the use of filters in the terminal or repeating station equipments. Obviously the simplification thus obtained is very remarkable.

The most perfect embodiment of this invention, as far as the technical means are concerned, is obtained if two intertwined pairs of conductors are available for the formation of a telegraph loop, for instance two related side circuits of a coil-loaded cable in spiral quad formation. In this case each quad offers two normal speaking connections and a telegraphic connection fit for duplexing. The means employed in the side circuits for increasing inductivity are not

subjected to magnetization by the current flowing in the telegraph loop, so that there is no danger of the loading coils or the iron whipping getting polarized or the telephone transmission impaired by flutter effects.

In the drawings affixed to this specification and forming part thereof two diagrams of connections embodying my invention are shown by way of example.

Each modification comprises a long distance cable with quadded conductors 1, 2, and 3, 4 are the conductors of the quad which contains in the side circuits the speaking equipments 5 and 6, connected as usual. 9 and 10 are two differential repeating coils, to the centre taps of which the leads of a duplex telegraph set 12 are connected. A low-pass filter 11 serves for choking out the higher harmonics, e. g. those above 150 cycles per second, of the telegraphic impulses.

As shown in Fig. 2, I can further insert high-pass filters 7 and 8, choking sub-audio frequencies. The speaking equipment 5 and 6 and the telegraphic equipment 12 will then operate without any mutual disturbance, even in case that the side-to-side capacities have not been balanced. In Fig. 2, 1, 2 and 3, 4 are again the two side circuits of the quad, 5 and 6 the speaking equipments protected against sub-audio frequencies by high-pass filters 7 and 8, and 9 and 10 are the centre tap differential coils for telegraphy. 13 is a filter transmitting only frequencies up to 100 cycles and in which the current impulses of the telegraph set 14 operated with direct current are deprived of their higher harmonics. 15 is a band filter having a transmission range between 110 and 150 cycles. 16 and 17 are two alternating current telegraph instruments sets which are operated on the Morse plan, use being made of electric or other selective means for the working frequencies 120 and 140 C. P. M. and which for instance form connections between the telephone operators of the toll circuits 1, 2 and 3, 4 in order to prepare the long-distance calls.

Repeater equipments are dispensed with in the side circuits by inserting differential coils in the ends of each two circuits which shall be interconnected, and by further interconnecting the centre taps of the two branching coils, or in some other suitable way. According to requirements filters for the rejection of the speaking frequencies, amplifiers for the signaling frequencies, intermediate or terminal equipments for telegraphy and so on can be provided.

In a well-known manner the speeds and ranges can be increased by networks adapted to improve the arrival curve of the current, and by insertion of intermediate relay repeaters.

I wish it to be understood that I do not desire to be limited to the exact details of



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means and connections shown and described, for obvious modifications will occur to a person skilled in the art.

I claim:—

- 5 The method of increasing the economy of cables, which consists in arranging the conductors of the cable in spiral quad formation grouped to give two side circuits and

one phantom circuit and then using the phantom circuits for transmission of signal currents below the frequency of the telephone range only, and side circuits for the transmission of telephone currents. 10

In testimony whereof I affix my signature

OTTO SATTELBERG.